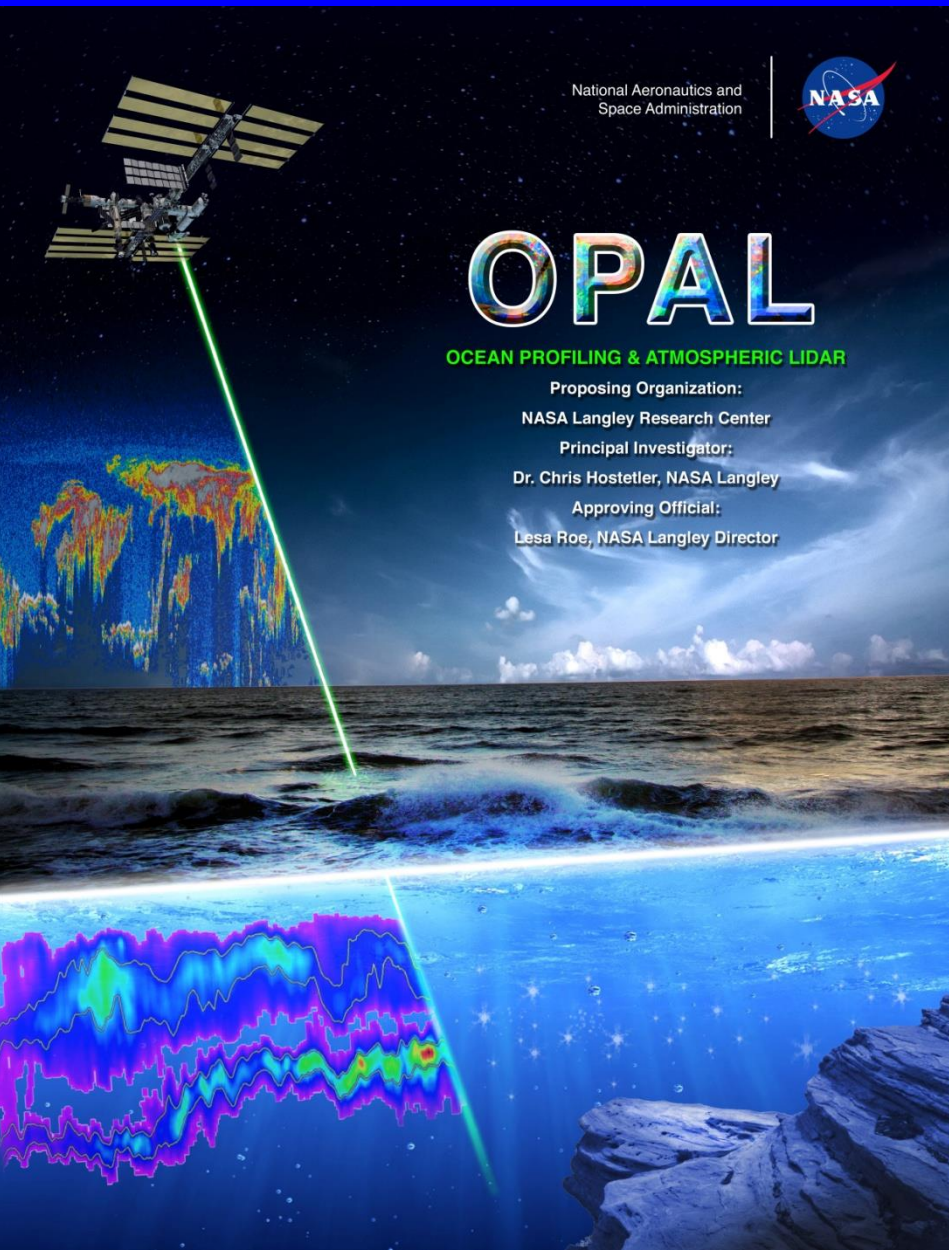
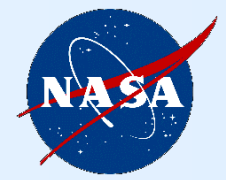


Spaceborne Lidar for Ocean Profiling

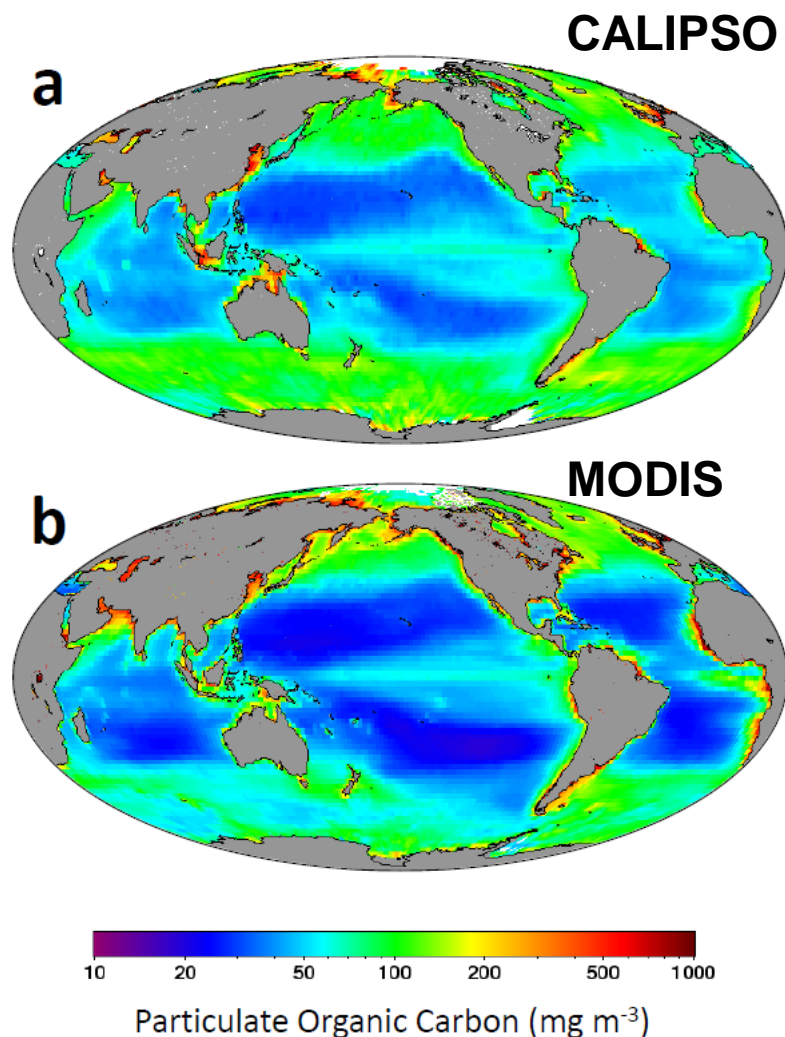
Ocean Profiling and Atmospheric Lidar (OPAL): An Earth Venture mission concept/proposal



- High Spectral Resolution Lidar (HSRL) deployed from International Space Station
- Provides profile measurements of K_d and b_{bp}
- Provides key aerosol and cloud observations above and beyond those from CALIPSO

Mission concept developed by HSRL+CALIPSO team and leading oceanographers at universities, GSFC, NRL, and NOAA

Building on successes with CALIPSO

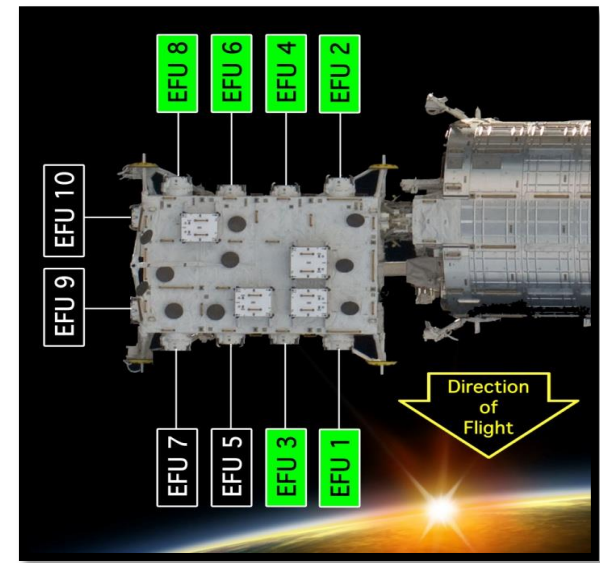
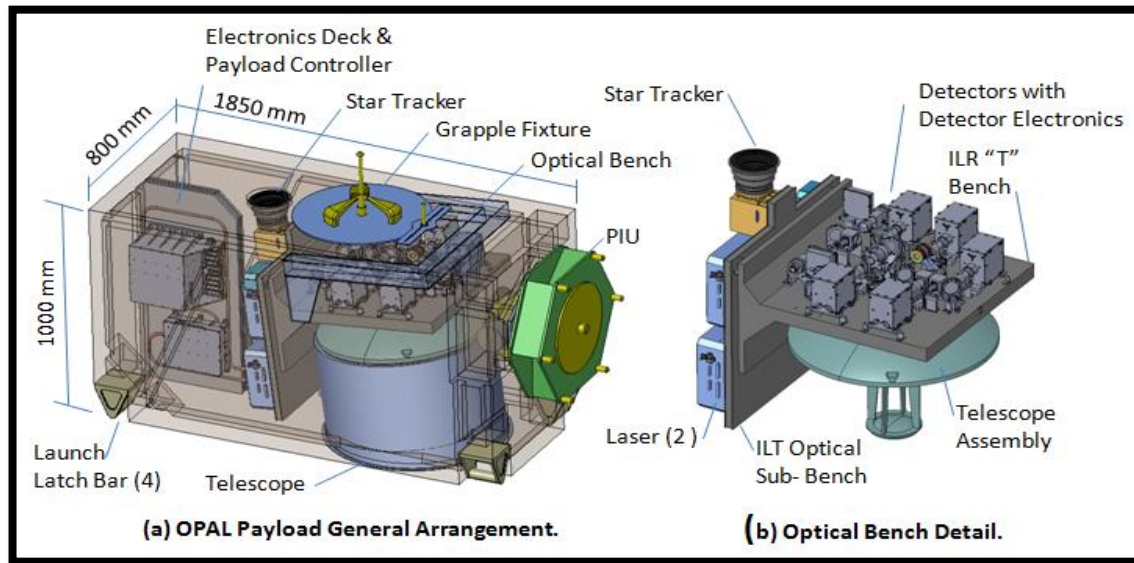
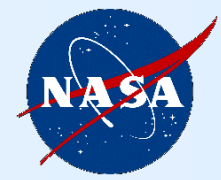


- POC and bbp retrieved from CALIPSO spaceborne lidar compared favorably to MODIS product
- CALIPSO retrieved in column-sense: non profiling

From: Behrenfeld et al., Space-based lidar measurements of global ocean carbon stocks, GRL, 2013

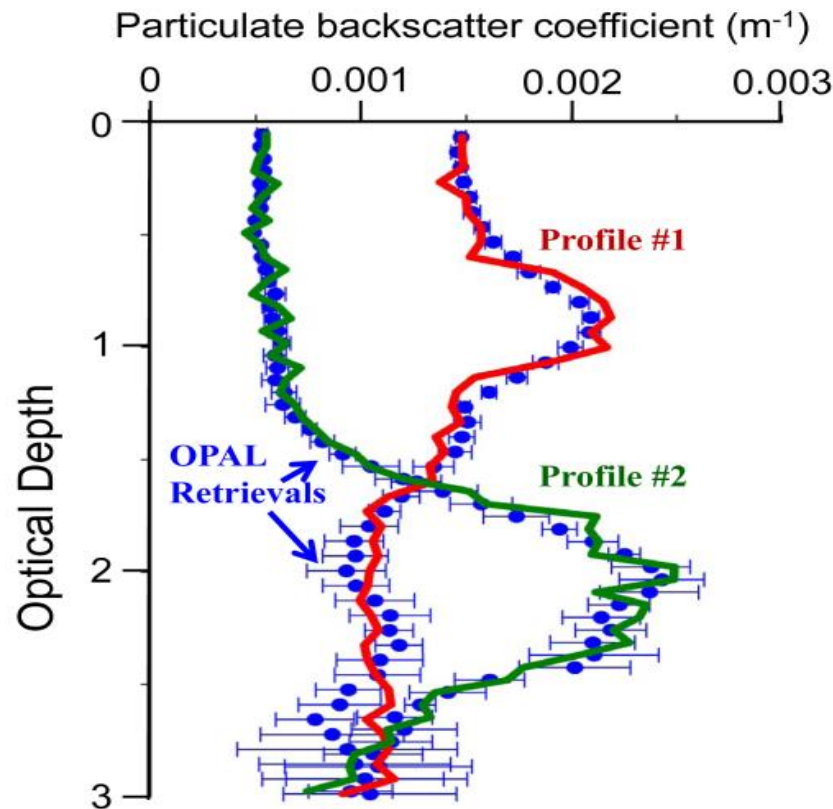
Data in each panel are climatological annual averages for the 2006 to 2012 period. Data are binned to 2° latitude by 2° longitude pixels.

Accurate spaceborne ocean profiling possible at reasonable mass, power, and cost

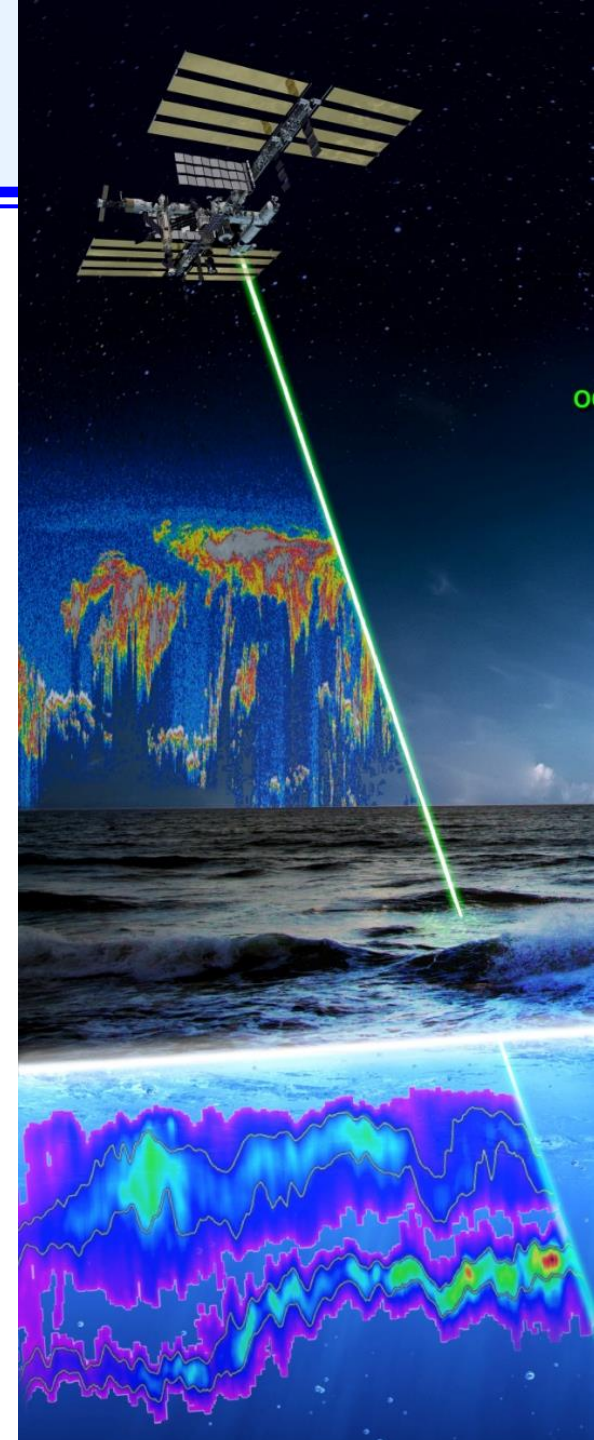


- Design study for previous Earth Venture Mission proposal showed that accurate ocean profiling was possible from space at reasonable cost
- Shown above is the OPAL configuration designed for a Japanese Explorer Module location on ISS

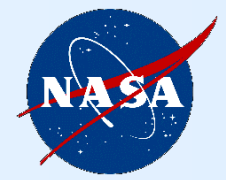
Simulations show that OPAL can provide profiles to 3 Optical Depths



- Objective: measure vertical structure of phytoplankton to reduce uncertainties in NPP
- OPAL measurements will penetrate 70% of the euphotic zone



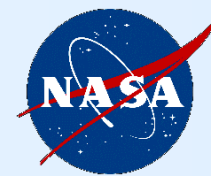
Airborne prototype lidar developed and demonstrated



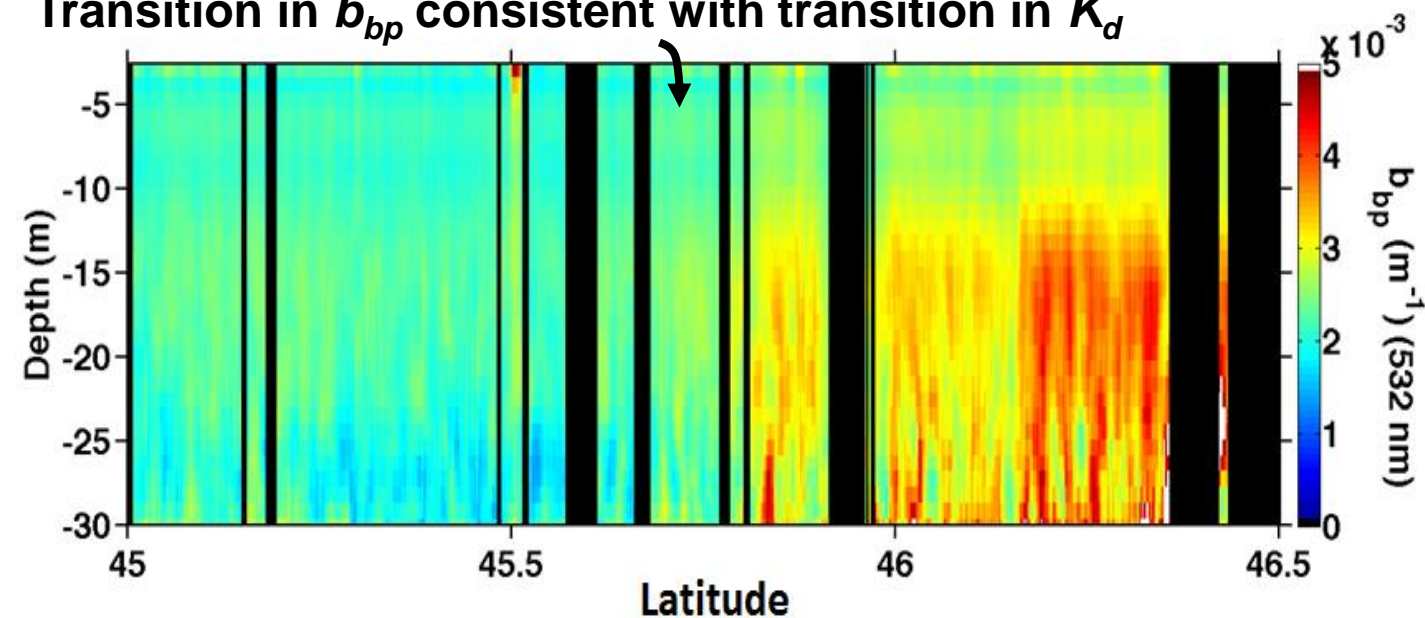
- High Spectral Resolution Lidar produces depth-resolved profiles of diffuse attenuation (K_d) and plankton backscatter (b_{bp})
- First measurements demonstrated in 2012 Azores campaign
- Findings guiding design of spaceborne instrument



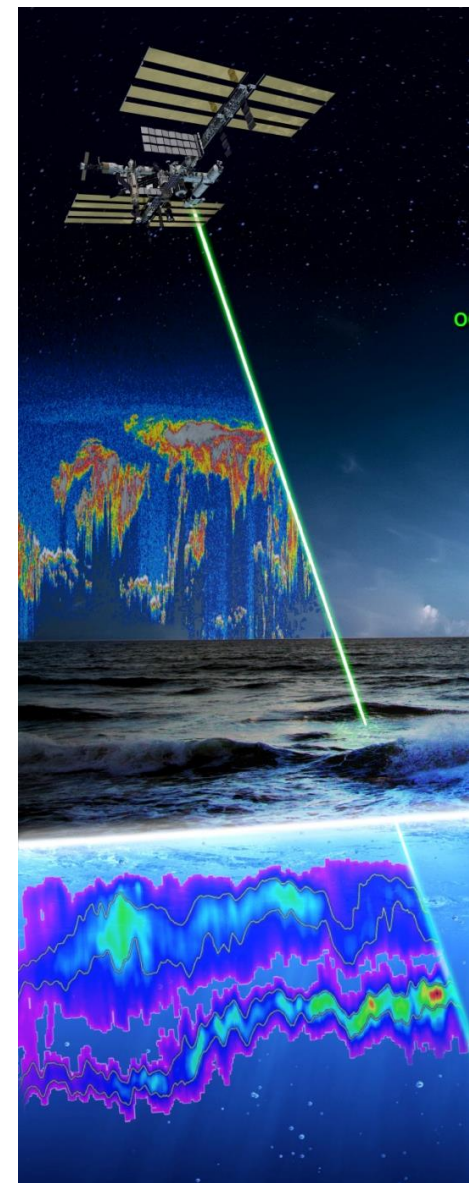
b_{bp} retrieved from HSRL-1 lidar in the transition region



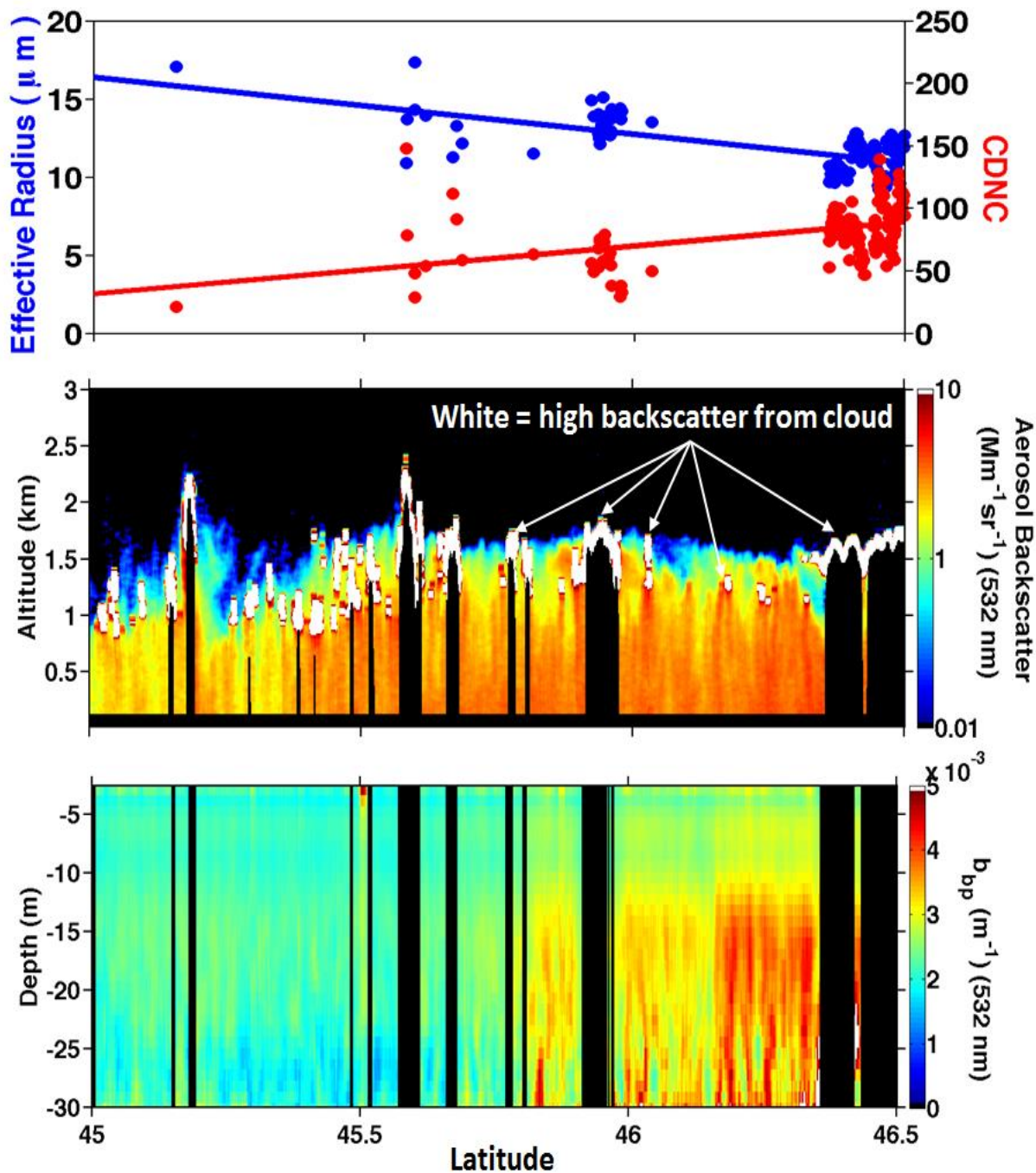
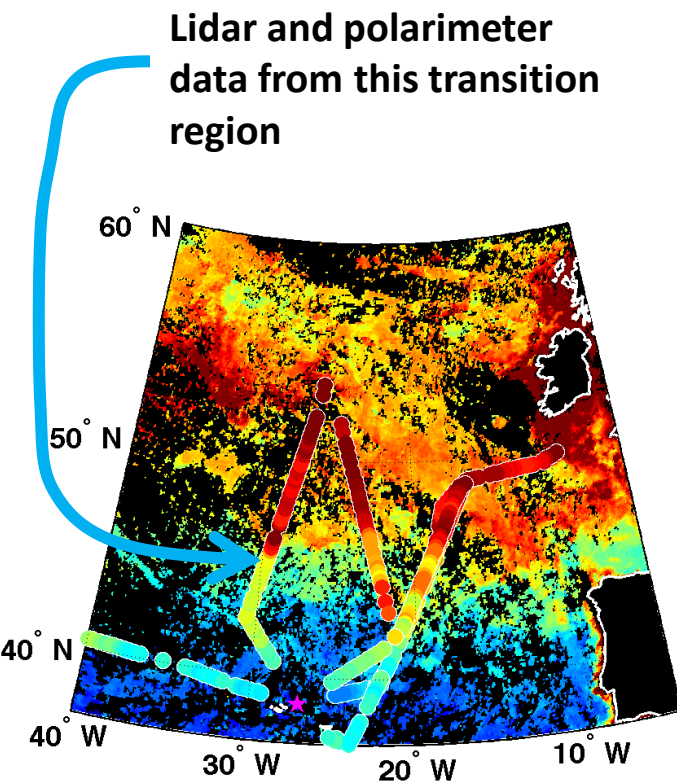
Transition in b_{bp} consistent with transition in K_d



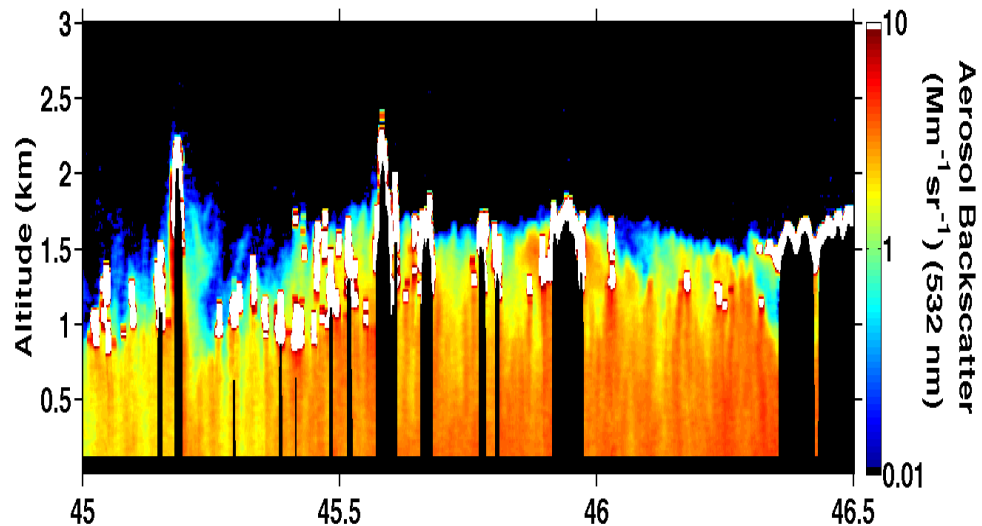
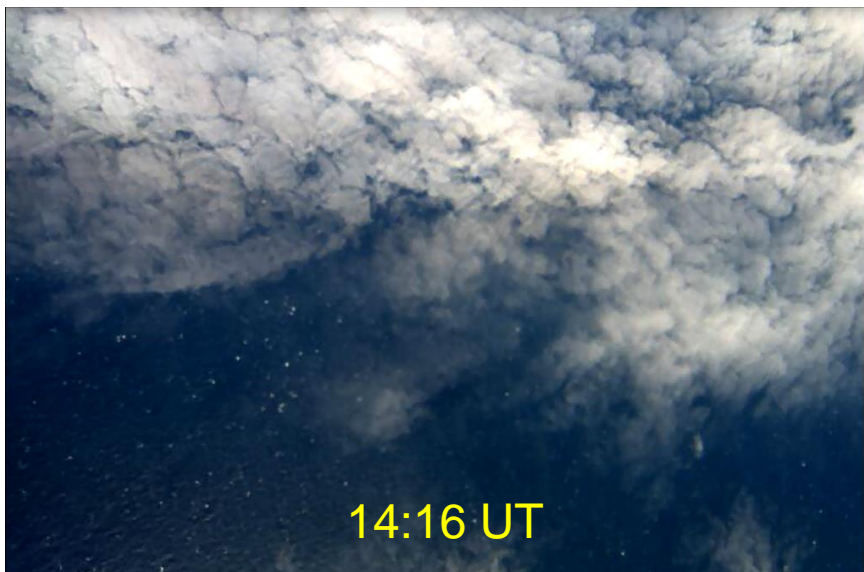
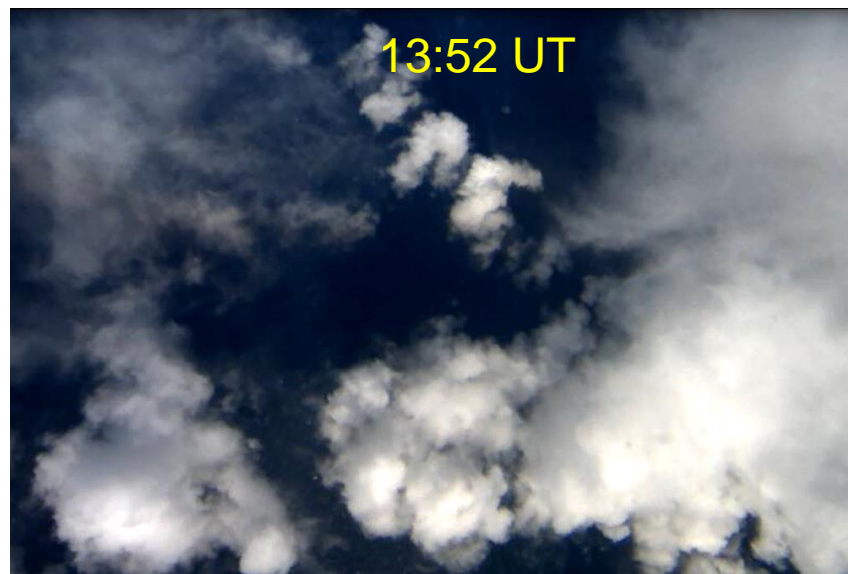
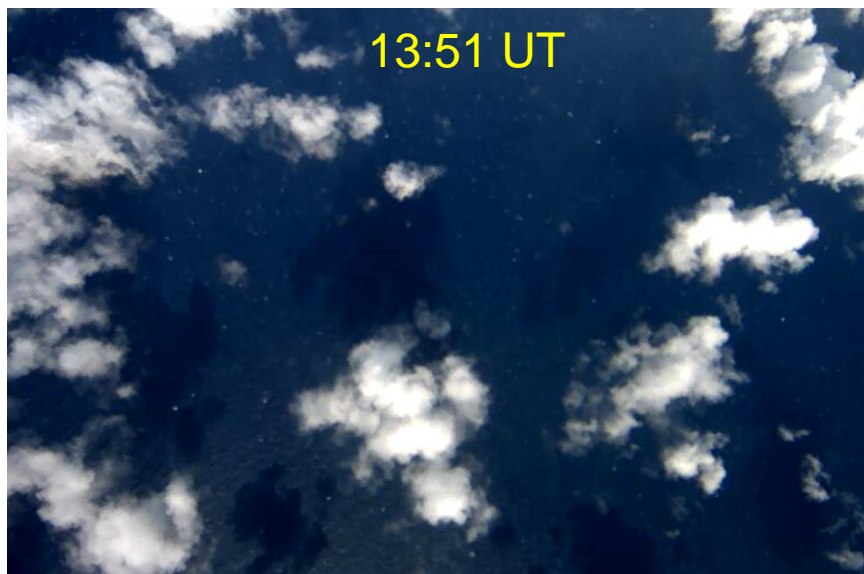
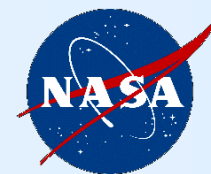
- Azores mission provided first-ever independent profiles of K_d and b_{bp} from lidar via the HSRL technique
- The lidar has since been modified to improve the retrievals
- SABOR will vet the techniques planned a space version of the lidar: OPAL – Ocean Profiling and Atmospheric Lidar



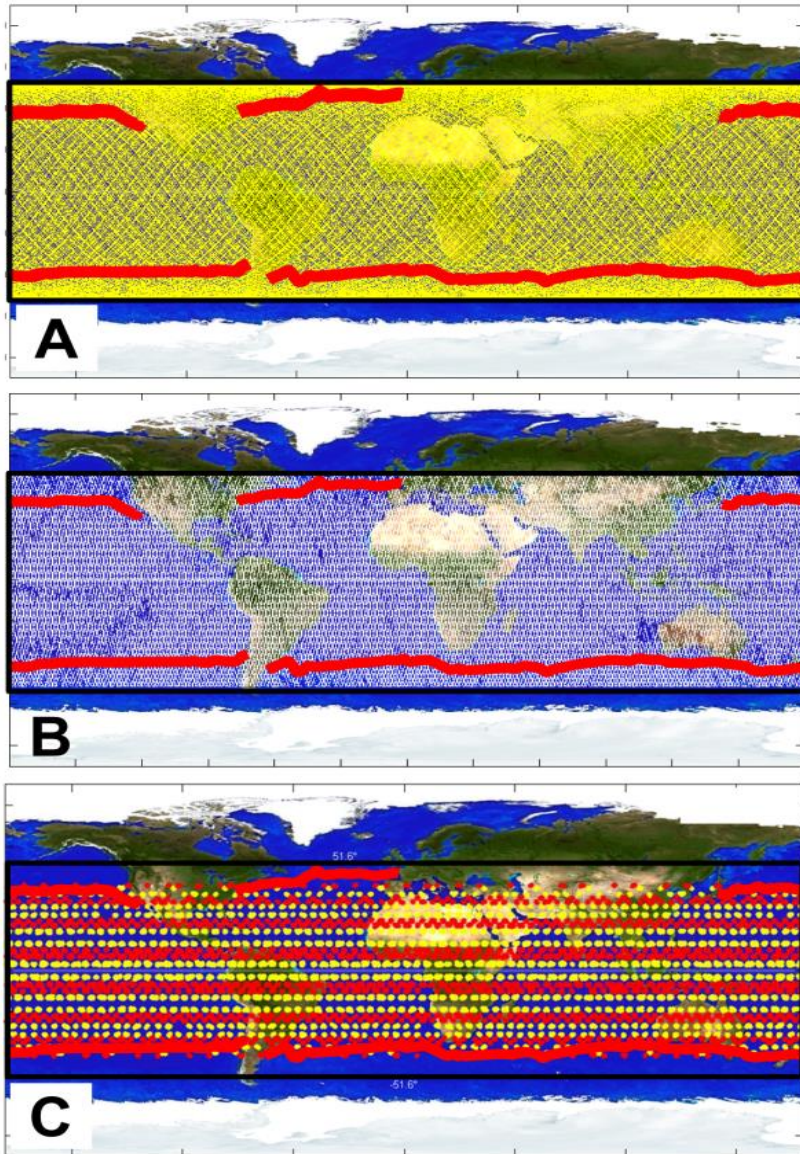
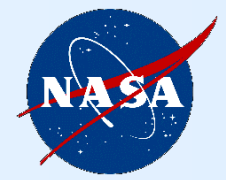
Ultimately, we are interested in understanding marine biogenic aerosols and their impact on the radiation budget. Airborne lidar and polarimeter observations provide coincident data on plankton abundance and aerosol and cloud properties.



Retrievals possible in broken cloud



ISS orbit provides good sampling even after considering cloud interferences

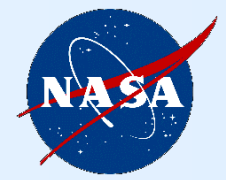


(A) clear-sky monthly OPAL sample density.

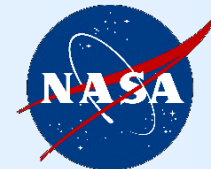
(B) Monthly sample density achieved by CALIOP without cloud interferences (i.e., cloud OD < 1) for ISS latitude range.

(C) Location of dawn-dusk match-up data (± 3 hours) over 24 hour (yellow dots) and 48 hour (red plus yellow dots). Heavy red lines show PSO boundary.

Synergy with concurrent ocean color sensor



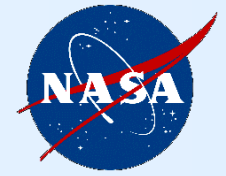
- A lidar on orbit concurrent with an ocean color sensor can provide
 - Training set to improve atmospheric correction
 - Data for lidar-constrained ocean color retrievals
 - Information on diurnal variability



Next Steps

- 2011 OPAL proposal received high science score but was rejected due to perceived cost/schedule risk associated with technology development
 - Much work has been done to retire technology risk
 - Flights of aircraft prototype guide design of instrument and algorithms.
- Plan to re-propose to Earth Venture Mission AO in 2015
- Exploring inclusion of similar concept in the next Decadal Survey

Grad student co-op program openings



- NASA Langley has just published 3 openings for the Pathways program
- Entitles student to pay and benefits as NASA Civil Servant while working at Langley
- We view this as an opportunity for collaboration
- Short fuse: applications due by 9 May
- Details on application process on USA Jobs:
 - <https://www.usajobs.gov/GetJob/ViewDetails/368763500>
 - <https://www.usajobs.gov/GetJob/ViewDetails/368763200>
 - <https://www.usajobs.gov/GetJob/ViewDetails/368763400>

Extras

Airborne Lidar Kd Retrieval at 532 nm

